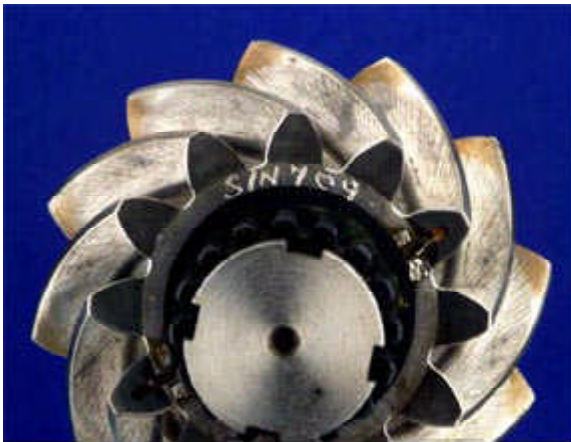


# Comparison Made of Operating Characteristics of Spiral Bevel Gears Manufactured Using Different Methods

Spiral bevel gears are important components on all current rotorcraft drive systems. These components are required to operate at high speeds, high loads, and for an extremely large number of load cycles. In this application, spiral bevel gears are used to redirect the shaft from the horizontal gas turbine engine to the vertical rotor. Because of the high expense of manufacturing these gears, methods that can achieve the same level of performance at reduced cost are highly desirable to aerospace gear manufacturers.

Gears manufactured for aerospace applications use high-quality materials and are manufactured to tight tolerances. Special manufacturing machine tools and computer numerically controlled coordinate measurement systems have enabled rotorcraft drive system manufacturers to produce extremely high-quality gears during their normal production. Because of low production rates for rotorcraft, these gears are manufactured in small batches, and thus are unable to benefit from the economics of high production numbers as in other industries.

In this investigation, two different manufacturing methods, face-milled and face-hobbed, were used to fabricate spiral bevel gears. For face-milled spiral bevel gears, grinding of the contacting surfaces is the final manufacturing step. At least two different specialty machines are needed to generate the teeth for face-milled spiral bevel gears. For face-hobbed gears, hard cutting is the final manufacturing process. The same machine is used to rough cut and finish cut the gears.

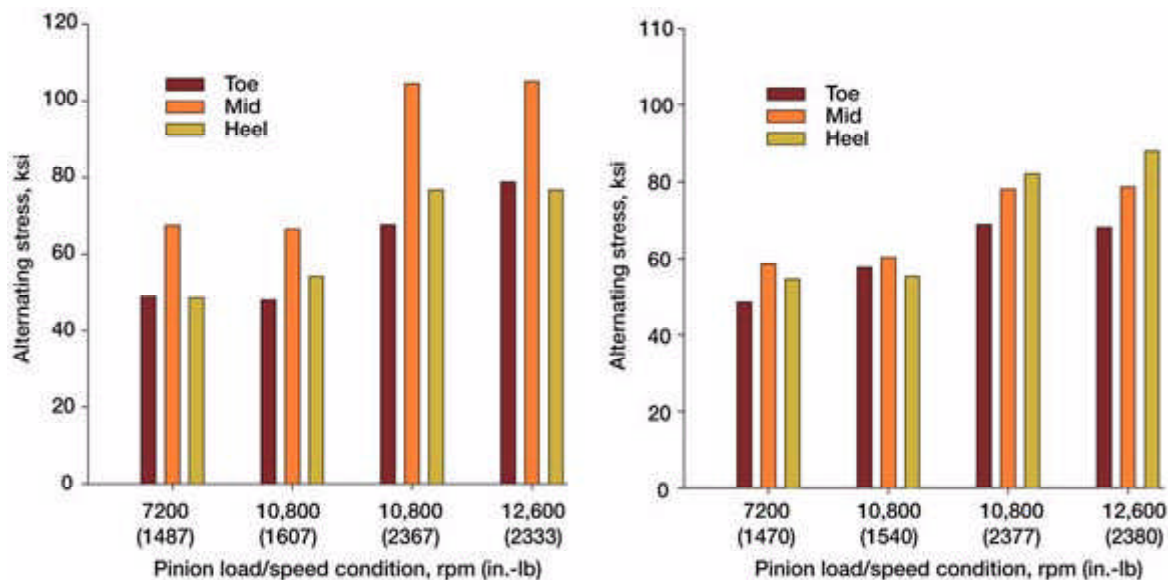


*Manufactured bevel pinions for the study conducted. Left: Face-milled. Right: Face-hobbed.*

Long description Difference between face-milled and face-hobbed gear teeth. The face-milled gear teeth change in height and tooth thickness across the face width of the gear. The face-hobbed gear is of equal height across the entire tooth width. The face-hobbed

tooth changes in tooth thickness across the tooth width and can reach the point where the teeth are pointed at the tip. This condition is avoided in practice so that the tip will not crack.

This study compared the operational behavior of face-milled spiral bevel gears with that of face-hobbed spiral bevel gears. Test hardware was manufactured to fit within NASA Glenn Research Center's Spiral Bevel Test Facility and to aerospace quality standards. Tests were conducted for stress, vibration, and noise. A comparison of the results attained indicated that the face-hobbed gears had a lower alternating stress level with a more even distribution of loading across the teeth, and slightly reduced levels of vibration and noise. Results of this study show that the face-hobbed method is a viable and lower-cost alternative for producing aerospace-quality spiral-bevel gears.



*Comparison of the alternating root stress levels of spiral bevel pinions. Left: Face-milled. Right: Face-hobbed.*

Long description Results of strain gauges that were located at the root region across the face width of the pinions of the two different designs. Data were taken from the strain gauges for four different combinations of speed and torque. The alternating stress was determined for each location at every speed/torque condition. The face-milled pinion had the highest stress values at the midpoint across the tooth width. The face-hobbed pinion had lower alternating stress at all conditions.

## Bibliography

Handsuh, Robert F.: Comparison of Experimental and Analytical Tooth Bending Stress of Aerospace Spiral Bevel Gears. NASA/TM-1999-208903, 1999.

Handsuh, Robert F.: Testing of Face-Milled Spiral Bevel Gears at High-Speed and Load. NASA/TM-2001-210743, 2001.

Handschuh, Robert F., et al.: Experimental Comparison of Face-Milled and Face-Hobbed Spiral Bevel Gears. NASA/TM-2001-210940, 2001.

**Find out more about this research <http://www.grc.nasa.gov/WWW/5900/5950/>.**

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